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LONWORKS™ Product Line Brief

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ntroduction

Local Operating Network (LON) technology makes possible a new generation of smart, low-cost products that communicate with one another and that can be linked together to serve applications in consumer electronics, factory automation, vehicle controls, commercial building controls, home automation, and other industries. To support and enhance this technology, Echelon has developed LONWORKS™, a set of components and tools that provides a complete, powerful, low-cost solution for incorporating distributed intelligence and control functions into products.

This product brief describes each of the major elements of LONWORKS. A separate document, the LONWORKS Applications Primer, describes how the elements of LONWORKS are used to implement distributed applications. The remainder of this document is organized as follows:

- Local Operating Networks
- LONWORKS Overview
- LONTALK™ Protocol, including features, services, and network management services
- NEURON CHIP™ Family, including hardware and firmware
- LONWORKS Transceivers
- LONBUILDER™ Developer's Workbench, including LONBUILDER hardware and application programming tools and the LONBUILDER Starter Kit

.ocal Operating Networks

A local operating network consists of intelligent devices, or nodes, that are connected by one or more communications media and that communicate with one another using a common protocol. Nodes are programmed to send messages to one another in response to changes in various conditions and to take action in response to messages that they receive.

The nodes on a LON may be thought of as objects that respond to various inputs and produce desired outputs. Linking the inputs and outputs of network objects enables the network to perform applications. While the function of any particular node may be quite simple, the interaction among nodes enables a local operating network to perform complex tasks. A benefit of local operating networks is that a small number of common node types may be configured to perform a broad spectrum of different functions depending on how they are linked in a network.

.ONWORKS Overview

LONWORKS offers a complete solution to companies for designing, building, and supporting LONs. Products developed using LONWORKS can easily be connected to form highly functional, local operating networks that are inexpensive to maintain and expand. In addition, LONTALK — the protocol used by LONWORKS to standardize communication on the LON — defines a standard way for devices to exchange control and status information. LONTALK enables previously disparate systems and products to interoperate and thereby provide new services and benefits.

Echelon's implementation of LON technology is available to anyone. Echelon has arranged for multiple sourcing of the key elements of LONWORKS, making it possible for any company to manufacture and sell LONWORKS-compatible products.

The following chart describes the major elements of LONWORKS and their benefits:

LONWORKS ELEMENT	DESCRIPTION	BENEFITS
LONTALK Protocol	A collection of services supporting communication among nodes across a wide variety of media	Reliable communications; compatibility and inter-operability; simplified network configuration and maintenance.
NEURON CHIPs	A family of VLSI components that manage communications and control in LONWORKS nodes	Small, low-power, low-cost, intelligent products
LONWORKS Transceivers	Modules that provide the physical connection between a LONWORKS node and communications media	Low-cost installation of distributed systems
LONBUILDER Developer's Workbench	An integrated, object-oriented platform including hardware and software for designing and testing LONWORKS nodes and networks	Reduced development costs; fast time-to-market

The LONTALK Protocol

The LONTALK protocol is a collection of services that supports reliable communication among nodes and makes efficient use of the communications medium. Conformance with the LONTALK protocol provides three primary benefits:

- Insulates the developer of LONWORKS-compatible products from the detailed design of reliably moving information throughout a local operating network.
- Provides installers of LONWORKS networks enormous flexibility in selecting and configuring nodes to meet a particular applicatior
- Ensures the predictability of network behavior under all conditions.

LONTALK Protocol Features

The LONTALK protocol has been designed for applications involving sense, control, and identification functions. The following section describes the key features of the LONTALK protocol, along with the features that support each requirement:

1 Reliability – The LONTALK protocol supports end-to-end acknowledgments with automatic retries. When this service is used, a node sending a message will expect an acknowledgment from all intended receivers and will automatically retransmit the message unles all intended receivers respond. Another service, called Request/Response, allows a sending node to confirm that a requested action was successfully carried out by the receiver.

2 Multi-Media – The LONTALK protocol supports communications on a variety of wired and wireless media, including the following:

- Power Line
- Radio Frequency
- Twisted Pair
- Coaxial Cabling
- Infrared
- Fiber Optic

In addition, specifications are provided to development of transceivers to meet special needs.

3 Response Time – The LONTALK protocol uses a proprietary collision prediction algorithm that permits a channel to carry its maximum capacity, rather than have its throughput degrade due to excess collisions. In addition, collision detection is optionally supported on certain media, including twisted-pair; this further enhances response time in cases where collisions do occur. At the fastest LONTALK data rate of 1.25 million bits/second, the LONTALK protocol supports over 500 transactions per second. For applications that must limit the maximum delay incurred by nodes with high-priority messages, the LONTALK protocol offers an optional Priority feature. Using priority, the highest priority node is guaranteed access to the medium as soon as transmission of any message in progress is completed.

4 Security – The LONTALK protocol includes a powerful service, called Authentication, that defeats unauthorized access to networks without using complex encryption of data that can increase cost per node and reduce throughput.

5 Low Product Cost – Many LON nodes are small, simple devices: light switches, temperature sensors, on-off controls, etc. Such devices cannot tolerate substantial increases in size and cost. The LONTALK protocol has been designed for implementation using a single, low-cost, VLSI chip that can be economically and practically incorporated in these low-cost devices.

6 Interoperability – A major goal of the LONTALK protocol is to give developers, from the same or different companies, the ability to design products that will be able to interact with one another. The LONTALK protocol provides a common applications framework that ensures interoperability using powerful concepts called network variables and Standard Network Variable Types (SNVTs), described below in more detail.

Network Variables insulate developers from the details of sending and receiving messages among nodes. Developers are able to think of nodes as objects, with network variables as object inputs and outputs. Developers can define network variables to be of a particular type, such as an integer, or a Boolean value, or a structure with multiple data fields. By only allowing links between inputs and outputs of the same type, network variables enforce an object-oriented approach to product development and thus greatly simplify the process of developing and managing distributed systems.

To further support interoperability, Echelon has defined a rich list of Standard Network Variable Types, or SNVTs. LONTALK supports as many as 255 SNVTs, with most applications served using the 50 or so SNVTs currently defined. The definition of a SNVT includes units, a range, and an increment. While network variables of any arbitrary type may be defined, the use of SNVTs enables developers of LONWORKS networks to identify and document their network variable inputs and outputs over the network. This is accomplished by storing within the node two key pieces of information about each of the node's network variables: the SNVT ID number and a text string. Using standard network management commands, a LONWORKS node can extract the SNVT information (ID # and text string) from any other node. The ability to extract this information from the

nodes themselves can greatly simplify installation and maintenance of LONWORKS nodes and networks.

The following are examples of SNVTs. The complete list of SNVTs will be available in the LONWORKS certification guidelines.

Variable Type	Units	Range	Increment
Temperature	Fahrenheit	-3,200 to +3,200	0.1 degree
Temperature	Celsius	-3,200 to +3,200	0.1 degree
Rel Humidity	Percent	0 to 100%	1/256%
Switch State	Boolean	Open(F), Closed(T)	N/A
Device State	Boolean	On(T), Off(F)	N/A
Day of Week	Enumerated List	M,T,W,Th,F,Sat,Sun	N/A
Date	MM,DD,YYYY	0-12, 0-31, 1-3000	N/A
Real Time	HH:MM:SS	00:00:00 to 23:59:59	1 second
Elapsed Time, L	Seconds	0 to 65,000	1 second
Elapsed Time, S	Milliseconds	0 to 650	0.01 seconds
Elapsed Time, D	Days	0 to 6,500	0.1 days
Elapsed Time, H	Hours	0 to 6,500	0.1 hours
Event Count	Counts	0 to 65,000	1 count
Encoder Count	Counts	-32,000 to +32,000	1 count
% of Full Scale	Percent	0 to 100%	1/256%
Alphanumeric	ASCII Characters	31 characters	N/A
Alphanumeric	Kanji Characters	15 characters	N/A
Alphanumeric	Int'l Char Set	15 characters	N/A
Phone State	Enumerated list	On-hook(0), off-hook(1), busy(2), ringing(3), connected(4), etc.	N/A
Energy	Kilowatt-Hours	0 to 650	0.01 kwh
Power	Watts	0 to 65,000	1 watt
Voltage - AC	Volts AC, RMS	-3,200 to 3,200	0.1 volts
Voltage - DC	Volts DC	0 to 25.6	0.1 volts
Voltage - DC	Microvolts DC	-3,200 to 3,200	0.1 µvolts
Current - AC	Amps AC, RMS	-3,200 to 3,200	0.1 amps
Current - DC	Milliamps AC	0 to 25	0.1 milliamps
Resistance	Ohms	0 to 65,000	1 ohm
Resistance	Kilohms	0 to 65,000	1,000 ohm
Volume	Gallons	0 to 65,000	1 gallon
Volume	CCF	0 to 6,500	0.1 ccf
Volume	Liters	0 to 65,000	1 liter
Flow	Gallons/hour	0 to 6,500	0.1 gph
Flow	Liters/hour	0 to 6,500	0.1 lph
Weight	Lbs	0 to 4,096	1 oz.
Weight	Kilograms	0 to 6,500	100 grams
Speed	Miles/hour	0 to 256	1 mph
Speed	Km/hour	0 to 256	1 kmh
Pressure	Lbs/sq-in gauge	-3,200 to 3,200	0.1 psi
Pressure	Pascals	-32,000 to 32,000	1 pascal
Pressure	Inches-Hg	-320 to 320	0.01 in Hg
Sound Level	dBrnc	-320 to 320	0.01 dB
Voltage	dB microvolts	-320 to 320	0.01 dB µv

ONTALK Protocol Services

The LONTALK protocol design follows the International Standards Organization's Reference Model for Open Systems Interconnection (ISO OSI), which prescribes the structure for open communications protocols. The following chart shows the features of the LONTALK protocol according to the ISO OSI Model, along with the benefits of each set of services.

ISO Layer	LONTALK Protocol Services	Benefits
7. Application	Standard Network Variable Types	Ensures compatibility and interoperability.
6. Presentation	Network Variables and Foreign Frame Transmission	Facilitates use of LONTALK for inter-network gateways.
5. Session	Request-Response Service	Guarantees that desired action has occurred.
4. Transport	Acknowledged and unacknowledged unicast and multicast	Reliability and efficiency.
	Authentication	Network security.
	Common ordering Duplicate detection	Elimination of errors caused by noise and lost messages.
3. Network	Addressing Learning routers	Multi-media networks, easy expansion and reconfiguration.
2. Data Link	Framing 16-bit CRC	Data integrity.
1.5 Media Access	Predictive CSMA with optional collision detection and optional priority	Efficient use of the medium. Consistent response time under variable network loads. Immediate network access when required.
1. Physical	Twisted pair, power line, radio frequency, coaxial cable, infrared, fiber optic Multiple data rates	Low-cost installation on multiple media.

sic Message Services

The protocol offers four basic types of message service:

- **End-to-end acknowledged service** — a node sends a message to a node or group of nodes and each receiver sends an acknowledgment.
- **Request/response service** — a node sends a message to a node or group of nodes and each receiver sends a response.

- **Unacknowledged repeated service** — a node sends a message to node or group of nodes multiple times and expects no response .
- **Unacknowledged service** — a node sends a message to a node or group of nodes and expects no response.

In addition to application message services, the LONTALK Protocol supports configuration, expansion, diagnosis, and maintenance of LONWORKS networks.

Network Management Services

LONTALK Network Management Services are a formal part of the LONTALK protocol. Support for these services is contained in every LONWORKS node. This guarantees that all nodes, regardless of origin, can respond to LONTALK commands from nodes designated to perform network management functions. Below is a partial list of services supported by network management messages:

- Find unconfigured nodes and download network addresses.
- Stop, start, and reset node applications.
- Access node communication statistics.
- Configure routers and bridges.
- Download new application programs.
- Extract the topology of a running network.
- Change network variable configuration table — includes the type of protocol service used to send the network variable, whether authentication is used, and if the variable is sent in a priority slot.

In order to guarantee security, network management messages may optionally be subjected to authentication, independent of application messages.

LONTALK Addressing

The LONTALK protocol supports a hierarchical address structure.

1. **Domain** — The top level of the hierarchy is the *domain*. Its ID is the system identifier. For example, if different LONWORKS networks are implemented on a shared communications medium such as RF, different domain identifiers can be used to keep the networks completely separate. A node may belong to a maximum of 2 domains. The domain identifier is selectable to be 0, 1, 3, or bytes long.
2. **Subnet** — The second level is the *subnet*, with up to 255 subnets per domain. A subnet is a logical grouping of nodes on a single channel (i.e., medium) or multiple channels connected with bridges. Subnets support learning routers.
3. **Node** — The third level is the *node*, with up to 127 nodes per subnet. A maximum of 32,385 nodes (255 subnets x 127 nodes per subnet) may be in a single domain.
4. **Group** — Nodes may be grouped. Groups of nodes may span several subnets within a domain. Up to 255 groups may be specified, and up to 63 nodes may be in a group for acknowledged message service; every node in the domain may be in a group for unacknowledged message service. A single node may be a member of up to 15 groups. Membership in a group allows many nodes to receive a single message on the network using a single-byte group address, thereby reducing network loading.

5. **Unique ID** — Each node carries a unique 48-bit ID assigned during manufacture. This ID is typically used as a network address only during installation and configuration. It may also be read and used by applications programs as a unique product serial number. The unique ID ensures that every node in a LONWORKS network has a unique address.

Nodes are addressed using one of five addressing formats:

Address Format	Destination
Domain	All nodes in the domain
Domain Subnet	All nodes in the subnet
Domain Subnet Node	Specific node within a subnet
Domain Group	All nodes in the group
Domain Unique-ID	Specific node

Additional information about the LONTALK protocol is provided in the NEURON C™ Programmer's Guide.

ıe NEURON CHIP ıamily

NEURON CHIPs are sophisticated VLSI devices that make it possible to implement very low-cost, LONWORKS-compatible products. Through a unique combination of hardware and firmware, NEURON CHIPs provide all the key functions required of LON nodes:

- Process all LONTALK protocol messages.
- Sense inputs and manipulate outputs.
- Implement application-specific functions.
- Store installation-specific parameters.

URON CHIP Family

rdware

The first two members of the NEURON CHIP family are designated the 3120 and the 3150. Both devices enable LONWORKS-compatible products to be implemented using a minimal number of additional parts.

e NEURON® 3120

The 3120 is a complete system on a chip and contains the following:

- Three 8-bit Processors:
  - two processors dedicated to LONTALK protocol processing.
  - a third processor dedicated to the node's application program.

- Eleven application I/O pins, usable in many different combinations:
  - 11 individually configurable digital inputs or outputs.
  - a parallel interface to an external microprocessor, with 8 da and 3 control lines.
  - 8 digital I/O pins, plus a 3-pin serial interface.
- A programmable, 16-bit counter/timer chain that can be multiplexed to 4 of the digital I/O pins for time-domain inputs and outputs.
- A complete memory subsystem including:
  - 10 Kbytes of ROM pre-programmed with the NEURON CHIP firmware.
  - 1 Kbytes of RAM for variables and buffers
  - 512 bytes of EEPROM for network parameters and applicatio program storage.
- A 48-bit NEURON CHIP ID unique to every device, irreversibly programmed into 6 of the EEPROM bytes.
- A Service pin for facilitating network installation.
- A 5-pin communications port that connects to either an external LONWORKS transceiver or through a simple interface to baseba media such as twisted pair wiring.
- Clock-divide circuitry that allows the 3120 to be operated at a range of input clock rates, from as high as 10 MHz to as low as 625KHz for low-power applications, while preserving key prot timing and I/O parameters.
- Wake-up, watchdog timer, and other circuitry.

The 3120 is designed for use in LONWORKS nodes where size and co are most critical and incorporates much of the functionality of a LONWORKS node in a single, 32-pin device.

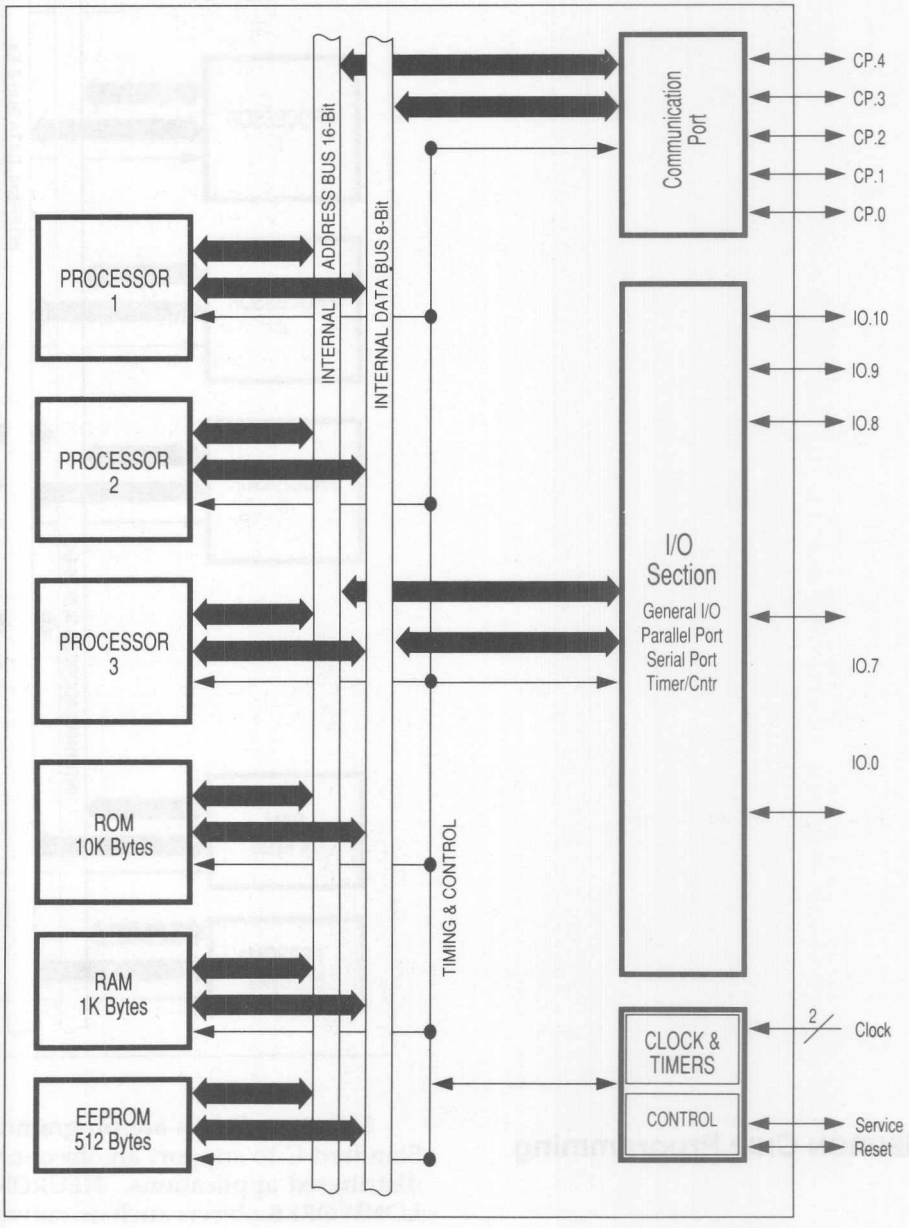
The NEURON® 3150

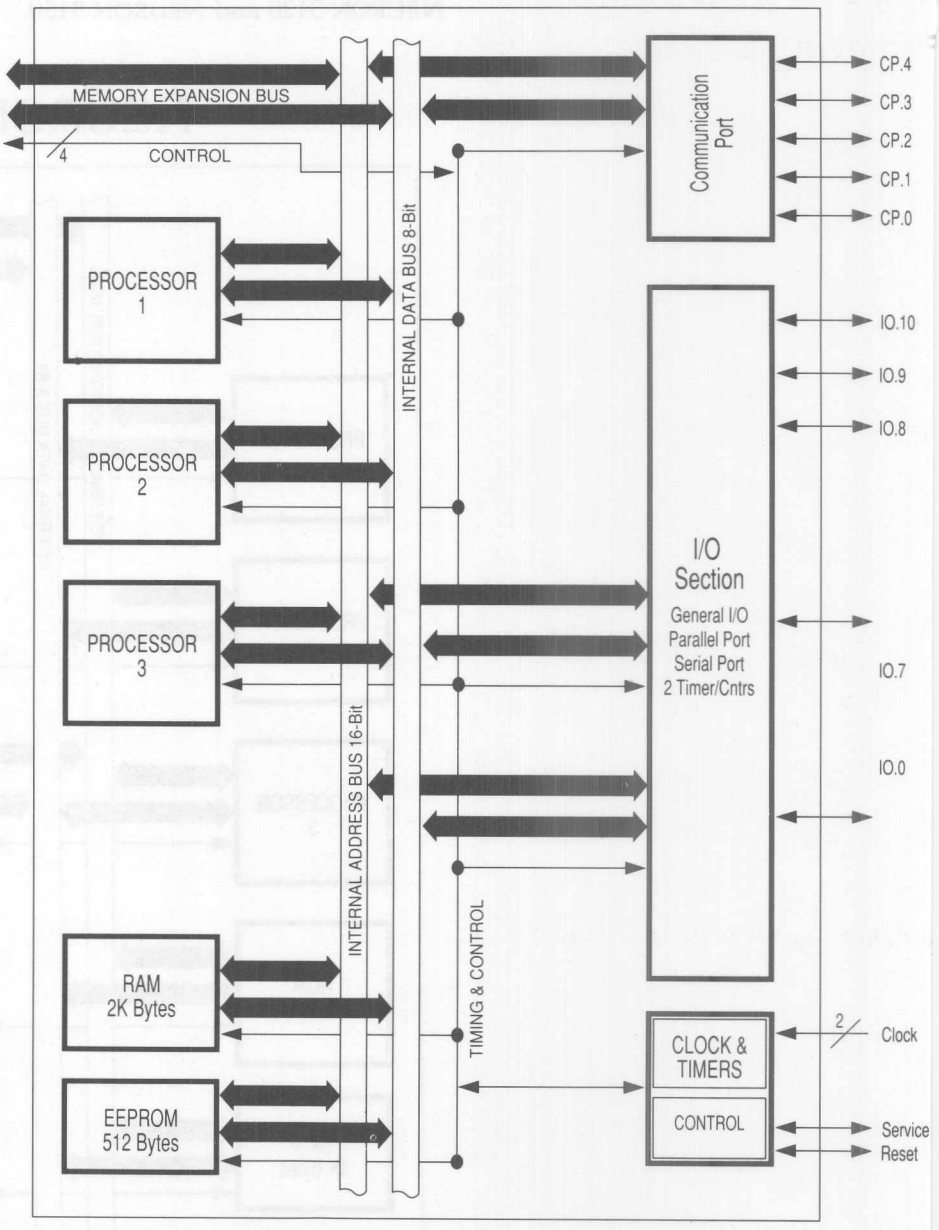
The 3150 is designed for LONWORKS nodes that perform more complex functions and that may require more memory or I/O capability than provided on the 3120. The 3150 is identical to the 3120 except for the following:

- The 3150 has no on-chip ROM. Instead, the 3150 offers a full external memory interface, supporting up to 64Kbytes of externa memory, of which 42Kbytes may be used for the node applicati program. In addition, the NEURON 3150 has 2Kbytes of RAM.
- The 3150 has a second 16-bit counter/timer for applications I/O functions.

The following diagrams show the principal hardware features of the NEURON 3120 and NEURON 3150.

NEURON 3120





NEURON CHIP Programming

NEURON CHIPs are programmed in NEURON C, which extends ANSI Standard C to support an object-oriented approach to developing distributed applications. NEURON C provides direct support for LONWORKS objects such as network variables and SNVTs. The language also provides a new statement called the "when" statement that is used to schedule execution of user tasks based on pre-defined and user-defined events. In addition, NEURON C provides a syntax for declaring a wide range of I/O objects that are supported by the NEURON CHIP application I/O hardware. All services of NEURON C leverage the run-time support provided by the NEURON firmware.

NEURON CHIP Family Firmware

The NEURON CHIP firmware provides run-time support for LONWORKS objects and services defined in NEURON C. The firmware coordinates activities in LONWORKS networks and manages network communications and hardware devices. The firmware contains the following:

- The LONTALK protocol communications software, including network management functions and network variable processing.
- An event-driven scheduler.
- Run-time support for applications I/O objects.
- Arithmetic, logical, conversion, and other application routine libraries.

The NEURON CHIP firmware is designed to keep programs short and to simplify NEURON CHIP programming by handling many low-level functions automatically. For example, a flexible scheduler manages NEURON CHIP resources and controls program flow. The applications I/O run-time support allows programmers to produce complex outputs, such as pulse-width modulated waveforms, using a single programming statement. Additionally, processing of all LONTALK messages is handled transparently. Providing these functions in firmware reduces the programming burden and also results in substantially shorter compiled programs.

The need for program efficiency is most critical for NEURON 3120 applications, because the NEURON 3120's 512 bytes of EEPROM store both the node application program and all network parameters. The NEURON firmware makes it possible to fit useful applications in the NEURON 3120's small programming space. NEURON 3150 programs also benefit from the firmware services, because a portion of the external memory is always dedicated to NEURON CHIP firmware. Thus, NEURON 3150 programs are also easier to write and require less space than comparable microcontroller programs.

NEURON CHIP I/O Objects

External hardware devices are managed with device drivers for a variety of input/output objects directly mapping into the input/output capabilities of the NEURON CHIP. Device drivers are included for digital, parallel, serial, frequency, counter, pulse-width, pulse-count, one-shot, triggered count, quadrature, and triac devices. Device drivers are also included for the NEURON CHIP timers, providing millisecond and second timers that activate user tasks when they expire.

Certain events are defined that are associated with changes in input values. These trigger the scheduler to execute associated user code when changes occur.

The following interfaces are supported in the NEURON CHIP firmware:

Application Input/Output Modes		
Interface Supported	**Type**	**Pins Supported**
Digital	Bit I/O	IO.0 through IO.10
	Nibble I/O	IO.0 through IO.7
	Byte I/O	IO.0 through IO.7
	Edge Detect	IO.0 through IO.7
Parallel	Parallel I/O	IO.0 through IO.7
Serial	Asynchronous Serial I/O (300, 1200, 2400 bps)	IO.8 (input) and IO.10 (output)
	Clocked Serial I/O	Paired Adjacent Pins
	NeuroWire I/O	IO.8 through IO.10

Timer Counter Input/Output Objects			
		Parameters	
	Object Type	**Minimum Resolution**	**Maximum Measurement**
Input Objects	On-time	0.2 µS	1.677 sec
	Pulse-count	1 count	65,535 counts
	Period	0.2 µS	1.677 sec
	Quadrature	1 count	± 32,767 counts
	Totalizer	1 count	65,535 counts
	Object Type	**Minimum Resolution**	**Maximum Output**
Output Objects	Triggered count	1 count	65,535 counts
	Pulse-width	0.4 %	100% duty cycle
	Pulse-count	1 count	65,535 counts
	Frequency	0.4 µS	3.355 sec
	One-shot	0.2 µS	1.677 sec
	Triac	0.2 µS	1.677 sec

The close integration between the firmware and the NEURON C programming language provides an easy to understand, easy to program systems-level solution to managing communication and control in smart nodes. By efficiently managing all of the details of network communications and input/output processing, the NEURON CHIP firmware allows designs to concentrate on solving application problems.

.ONWORKS
'ransceivers

For applications in which all nodes and their associated NEURON CHIPs are wholly contained within another product, such as a machine tool or an office machine, the circuitry in the NEURON CHIP's communications port enables nodes to be connected directly together via the communications port I/O pins. However, LONWORKS nodes that communicate over greater distances or over noisy media require a transceiver to provide the physical interface between the node and the medium on which it communicates. Transceivers encode and decode data bits transmitted and received in a format appropriate for the medium. For some media, such as twisted pair, the NEURON CHIP contains most of the transceiver circuitry, and some external interface circuitry is required to connect to the medium. For other media, such as powerlines and radio waves, an external transceiver is required to support a more complex encoding scheme.

For each medium, the LONWORKS Transceiver is a low-cost assembly that handles the medium's particular encoding scheme and provides the complete mechanical and electrical interface between the medium and the NEURON CHIPs communications port. Specifications for the following LONWORKS Transceivers are currently defined:

Medium	Data Rate	Range	Comments
Powerline	9600 bps	55 db attenuation in the presence of common powerline noise sources	Designed for implementation using a low-cost companion IC to the NEURON CHIP.
Radio Frequency	5 Kbps	30 feet indoors; 150 feet outdoors.	Low power mode supports battery operation.
Twisted Pair	78 Kbps	4,500 feet, with 64 nodes	Doubly-terminated bus.
	1.25 Mbps	1500 feet, with 64 nodes	Uses 1 pair for local powered option and 2 pairs when power is supplied over the network.

To support rapid development, transceiver evaluation modules will be available that implement the specifications of the powerline, radio frequency, and twisted-pair transceivers as a part of the LONBUILDER Developer's Workbench.

The LONBUILDER Developer's Workbench

The LONBUILDER Developer's Workbench is an integrated set of hardware and software tools that support rapid design, programming, debugging, implementation, and testing of LONWORKS nodes and applications. LONBUILDER speeds development by enabling developers to use object-oriented concepts, such as network variables and input/output objects, rather than low-level constructs.

LONBUILDER Developer's Workbench Hardware

LONBUILDER provides a development environment that operates with an IBM® PC/AT® or compatible computer. This development environment can grow from a single emulated application node to a completely distributed system of up to 24 emulated nodes and hundreds of remote nodes.

Network design, hardware design, and software design are all independent to allow hardware, software, and network development to proceed in parallel. Maintenance time is saved because nodes that have already been programmed need not be reprogrammed each time the network is reconfigured.

During development, LONWORKS-based applications will typically grow from a pair of communicating nodes to large networks of many nodes. Because the hardware development environment must grow with the application, LONBUILDER supports testing of one or two nodes but is capable of expanding to many nodes.

LONBUILDER provides an expandable hardware environment with the LONBUILDER Development Station and LONBUILDER processor boards. The development station includes two built-in nodes for managing and monitoring the developer's network and can accommodate up to six processor boards. An interface adaptor installed in the host PC provides high speed communications between the PC and up to four development stations.

LONBUILDER Processor Boards

LONBUILDER processor boards may be added to the LONBUILDER Development Station to create LONWORKS application nodes. The processor boards accept optional expansion boards that may be used for developing prototype I/O interfaces and transceivers. Optional LONBUILDER transceiver evaluation boards are available for twisted pair, RF, and powerline communications. The developer may also develop custom I/O or transceiver expansion boards.

To simplify network development, LONBUILDER tools are independent of the communications medium. Initial development may start with communications occuring over a backplane network built into the development station. Transceiver expansion boards can be added or changed at any time to change the network medium without affecting the software design. Communications across multiple channels and multiple media are supported with optional LONBUILDER Routers.

LONBUILDER NEURON Emulator

Nodes are initially developed on the NEURON Emulator, which is a LONWORKS node that supports source-level debugging and hardware prototyping. The LONBUILDER NEURON Emulator incorporates a 3150 NEURON CHIP with 64 Kbytes of RAM. Software may be executed independent of target hardware to enable software development to occur even before hardware is available. Each emulator board can have one or two expansion boards for testing with prototype I/O and transceiver hardware.

The emulator provides hardware support for fast application download, source-level breakpoints, single-stepping, reset/start/stop, and memory read/write protection. The emulator also provides a software controlled NEURON clock rate that may be set to 10 MHz, 5 MHz, 2.5 MHz, 1.25 MHz, and 625 KHz.

LONBUILDER Single Board Computer (SBC)

The LONBUILDER SBC is a complete single board computer that may be used within the LONBUILDER Development Station or used remotely with a transceiver and user-supplied power to create a physically distributed network environment. Once the application software is debugged on the emulator, it may be moved away from the development station using the LONBUILDER SBC. The LONBUILDER SBC incorporates a 3150 with 64 Kbytes of non-volatile RAM. The SBC accepts the same I/O and media interface expansion boards as the emulator so that prototype I/O and transceiver hardware may be tested in a remote node.

LONBUILDER Router

Networks with multiple channels and media may be constructed during development with the LONBUILDER Router. The LONBUILDER Router is a processor card incorporating two 3150 NEURON CHIPs and connections for two transceivers designed to provide routing between two network channels. The LONBUILDER Router may be configured as a learning router, a configurable router, or a bridge. When configured as a learning router, the LONBUILDER Router monitors network traffic to learn the network topology. The router uses the network topology information to selectively route packets between channels. When operated as a configurable router, the LONBUILDER Router can use routing tables specified with the LONTALK Network Management commands. When configured as a bridge, the LONBUILDER Router forwards all packets between the two connected channels.

The LONBUILDER Router may be housed inside the LONBUILDER Development Station or operated remotely with a user-supplied external power supply.

LONBUILDER Transceiver Evaluation Boards

Transceiver evaluation boards are optional expansion boards that may be installed on any LONBUILDER processor board to provide the physical interface to a LONWORKS network channel. Transceiver evaluation boards are available for twisted pair, powerline, and RF media.

LONBUILDER Twisted-Pair Transceiver Evaluation Board

The NEURON CHIP can interface directly with a backplane network to communicate within a limited distance. The Twisted-Pair Transceiver Evaluation Board can be used to extend prototype networks to the maximun topological and performance boundaries of LONWORKS on the twisted-pai media. The units are required in applications that require long distances and a large number of nodes on the network. Twisted Pair Transceiver Evaluation Boards are also required to support collision detection on twisted-pair networks.

The Twisted-Pair Transceiver Evaluation Board supports two data rates: 1.25 Mbps and 78 Kbps.

LONBUILDER Powerline Transceiver Evaluation Unit

The Powerline Transceiver Evaluation Unit provides the physical interface for 90-277 VAC powerlines. The Powerline Transceiver Evaluation Unit provides a 9600 bps data rate modulated on high frequency carrier signals. The Powerline Evaluation Unit is housed in a stand-alone enclosure that connects to an expansion board mounted on any LONBUILDER Processor Board. The stand-alone enclosure includes a power supply for the evaluation unit and provides a +5V, 1.4A output to support remote SBC.

LONBUILDER RF Evaluation Board

The LONBUILDER Radio Frequency Transceiver Evaluation Board provides the physical interface to a radio frequency network. The Radio Frequency Transceiver Evaluation Board provides a 5000 bps data rate using a 49 MHz carrier, and supports reliable communications within buildings at distances up to 30 feet.

LONBUILDER Application Programming Tools

The LONBUILDER application programming tools provide all the tools required to edit, compile, and debug NEURON C applications. The tools are integrated, thereby reducing training time and increasing productivity. The application programming tools include the LONBUILDER Integrated Development Environment and NEURON C Developer's Kit.

LONBUILDER Integrated Development Environment

Application programming is supported with the LONBUILDER Integrated Development Environment (IDE). The LONBUILDER IDE automates the development cycle and provides a common framework for all the software tools in LONBUILDER. The LONBUILDER IDE includes an object database that stores the definition of all objects defined by the user. The object database ensures consistency and simplifies use of LONBUILDER since all tools share a common definition of the application.

The LONBUILDER IDE incorporates a project manager that manages the configuration of objects within the object database and provides the developer with the capability of building an application based on the object database definitions. If application source files have changed, the project manager can automatically invoke the optional NEURON C Compiler to compile the application programs. Once an application is compiled, the project manager invokes the network management tools to build the network configuration information, load the application, and start execution.

The LONBUILDER IDE also includes an editor for creating application programs. The editor is integrated with the optional NEURON C Compiler so that errors identified by the compiler are easily found and corrected.

EURON C Developer's Kit

The NEURON C Developer's Kit includes the NEURON C Compiler and the NEURON C Debugger.

The NEURON C Compiler and Debugger are optional components of the LONBUILDER Integrated Development Environment. The NEURON C Compiler is a cross-compiler that uses NEURON C source code stored on the PC as input and generates code that is stored in the object database for subsequent downloading by the LONBUILDER IDE. The NEURON C Compiler generates code for both the NEURON 3120 and the NEURON 3150.

The NEURON C Debugger is a cross-debugger that runs on a PC host while debugging NEURON C applications running on from 1 to 24 NEURON Emulators.

The NEURON C Debugger provides a full-screen source-level view of application programs executing on LONBUILDER Emulators. The developer uses the source-level views to set breakpoints, start and stop program execution, and single-step through the programs. The programmer can also evaluate and modify program variables using the NEURON C symbolic names. The NEURON C Debugger can display the call stack and change the current context to any function within the stack.

etwork Management Tools

Traditional emulators and debuggers are not sufficient for developing distributed applications. They tend to focus on the development of software for a single processor and cannot be easily expanded to a networking environment. Moreover, developers must spend time creating custom tools for debugging and managing distributed applications.

LONBUILDER solves networking problems by including the tools required to define, configure, load, monitor, and control multiple nodes in a networking environment.

The Development Station software includes two network management tools: the LONBUILDER Network Manager and the LONBUILDER Protocol Analyzer. The LONBUILDER Network Manager provides the tools required to define, configure, load, and control LONWORKS networks. The LONBUILDER Protocol Analyzer provides capability to monitor, collect, and display network traffic and performance statistics.

LONBUILDER Network Manager

The LONBUILDER Network Manager uses the built-in network management node in a Development Station to send network management commands to Emulator, SBC, Router, and custom nodes within the development network.

The user defines a new network by using the network manager to defin network objects within the development network. Each node is defined in terms of its physical characteristics and the name of the application program for the node. Once the application program is written, the network manager creates the required information for configuring each noc and downloads the information over the network to the selected target hardware.

The network manager controls nodes over the network by providing us commands to put nodes online, take nodes offline, reset nodes, read node memory, write node memory, and test nodes. It also maintains a summary display of the status of all nodes on the network.

LONBUILDER Protocol Analyzer

The LONBUILDER Protocol Analyzer provides the capability to monitor, collect, and display network traffic and performance statistics. The protocol analyzer uses one of the two nodes built into the development station to monitor network traffic. Network traffic may be saved to a log file for later display. The protocol analyzer simplifies interpretation of the packets by decoding the packet contents and displaying a symbolic representation of the packets. For example, network variable transactions are displayed in terms of source node name destination node name, network variable name, and the new value of the network variable. Each packet is time stamped to support real-time performance analysis.

Packets can be filtered based on source node, destination node, packet type, and network variable. Source node and destination node filters can used to collect only those packets exchanged between a specific pair of nodes. Network variable filters can be used to limit the log to specific network variable updates.

The protocol analyzer also maintains network statistics and allows t user to display a summary of network performance, packet counts by pack type, and error rates.

LONBUILDER Starter Kit

The LONBUILDER Starter Kit contains all the tools necessary to begin LONWORKS development on a PC/AT or compatible computer. The starter kit contains a LONBUILDER Development Station with its enclosure, control processor, and PC interface adapter, and also includes the integrated development environment, network manager, and protocol analyzer software. The starter kit also contains two LONBUILDER NEURON Emulators and the NEURON C Developer's Kit. The starter kit can be used with the backplane network built into the development station, or may be used with optional LONBUILDER transceiver evaluation boards for powerline, radio frequency, and twisted-pair networks.

ardware Requirements

LONBUILDER requires an IBM PC/AT compatible computer with one available 8- or 16-bit expansion slot, EGA or VGA compatible graphics adaptor, 640 Kbytes RAM, extended or LIM 4.0 expanded memory with 1.5 MB available, MS-DOS® or PC-DOS® version 3.3 or 4.0, a Microsoft®-compatible mouse, and a hard disk with 10 MB of available space. LONBUILDER software is distributed on 1.2 MB 5 1/4" and 720 KB 3 1/2" diskettes.

ummary

Echelon is dedicated to making it easy and affordable to design, build, and support LONWORKS-compatible products. Any company may execute an Echelon OEM license agreement, purchase NEURON CHIPS, and manufacture LONWORKS-compatible products. To ensure conformance with the LONTALK protocol and guarantee product interoperability, Echelon will provide a certification program to ensure products' compatibility with LONWORKS.

In order to assure the wide availability and low costs required for successful LONWORKS products, Echelon has licensed two of the world's premier semiconductor manufacturers, Motorola and Toshiba, to manufacture and distrubute NEURON CHIPS. Echelon will continue to promote the availability of low-cost products by developing sources for low-cost implementations of transceivers and other elements.

To support rapid development and deployment of LON applications, Echelon manufactures the LONBUILDER Developer's Workbench and makes it available through several distribution channels.

LONWORKS offers a complete solution for many distributed applications. The LONTALK protocol, NEURON CHIPS, LONWORKS transceivers, and LONBUILDER Developer's Workbench enable reliable communications, low-cost products, simple installations, and rapid product development. Available to anyone, and easy to use, LONWORKS makes possible a new generation of systems based on smart, communicating products.